# Surgery II (Part 2) Orthopedics and Anesthesia

- Reference: Maheshwari's Orthopedics

Have any suggestions? Send them *here*.

## 1. Orthopedic Trauma: Introduction

▼ Classification of fractures

## Introduction

A fracture is defined as a **break in the continuity of a bone**. Fractures can occur due to **trauma, repetitive stress, or underlying pathological conditions**. The classification of fractures is based on various factors such as **etiology, displacement, relationship with the external environment, complexity, force applied, and fracture pattern**.

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# 1. Classification Based on Etiology

## (a) Traumatic Fracture

- Caused by **direct or indirect trauma**.
- Common causes: **Falls, road traffic accidents, sports injuries**.
- Example: **Fracture due to a fall from height**.

## (b) Pathological Fracture

- Occurs in a **bone weakened by an underlying disease**.
- Common causes: **Osteoporosis, metastatic bone disease, osteomalacia, Paget's disease**.
- Example: **Fracture in a bone affected by a tumor or osteoporosis**.

## (c) Stress Fracture

- Occurs due to **chronic repetitive stress on bone** without an acute injury.
- Common in **athletes and military recruits**.
- Often **not visible on initial X-rays**.
- Example: **March fracture (2nd or 3rd metatarsal stress fracture)**.

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# 2. Classification Based on Displacement

### (a) Undisplaced Fracture

- No significant movement of bone fragments.
- Can be detected **only on X-ray**.

### (b) Displaced Fracture

- Bone fragments are **misaligned** due to trauma, muscle pull, or gravity.
- Types of displacement:
  - **Shift** – Bone fragments move sideways.
  - **Angulation** – Bone is bent at an angle.
  - **Rotation** – Twisting of bone fragments.
- Example: **Fracture of the tibia with angulation**.

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## 3. Classification Based on Relationship with the External Environment

### (a) Closed Fracture

- Bone fracture does not communicate with the **external environment**.
- Overlying skin and soft tissues are **intact**.
- Example: **Simple transverse fracture of the humerus**.

### (b) Open Fracture (Compound Fracture)

- Bone breaks through the **skin and soft tissues**, exposing it to the **external environment**.
- Prone to **infection and osteomyelitis**.
- Types:
  - **Internally open fracture** – Bone pierces skin from within.
  - **Externally open fracture** – External object causes the bone to break and lacerates skin.
- Example: **Fracture of the tibia with skin breach due to trauma**.

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## 4. Classification Based on Complexity of Treatment

### (a) Simple Fracture

- Bone is broken into **two pieces**.
- **Easier to treat** with immobilization or internal fixation.
- Example: **Transverse humeral fracture**.

### (b) Complex Fracture

- Bone is broken into **multiple fragments**.
- **Difficult to treat** and often requires **surgical intervention**.
- Example: **Comminuted tibial fracture**.

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## 5. Classification Based on Quantum of Force Causing Fracture

### (a) High-Velocity Injury

- Caused by **severe trauma** (e.g., road traffic accidents, falls from height).
- Associated with **severe soft tissue injury** and **vascular damage**.
- Example: **Femur fracture due to a high-impact collision**.

### (b) Low-Velocity Injury

- Caused by **mild trauma** (e.g., simple falls).
- Less soft tissue damage, easier to heal.
- Example: **Colles' fracture (fracture of the distal radius due to a fall on an outstretched hand)**.

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## 6. Classification Based on Fracture Pattern

### (a) Transverse Fracture

- Fracture line is **perpendicular** to the long axis of the bone.
- Caused by a **direct blow or bending force**.

### (b) Oblique Fracture

- Fracture line runs **diagonally across the bone**.
- Caused by a **bending force with a component along the bone axis**.

### (c) Spiral Fracture

- Fracture line runs in a **spiral pattern**.
- Caused by a **twisting force**.
- Example: **Fracture of the tibia due to foot twisting**.

### (d) Comminuted Fracture

- Bone is **broken into multiple fragments**.
- Caused by a **crushing or high-impact injury**.

### (e) Segmental Fracture

- Two fractures occur at **different levels in the same bone**.
- Example: **Segmental fracture of the femur**.

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## 7. Fractures with Eponyms (Named Fractures)

Some fractures are named after the physicians who first described them:

- **Colles' Fracture** – Distal radius fracture with dorsal displacement.
- **Smith's Fracture** – Distal radius fracture with **volar displacement** (reverse Colles').
- **Galeazzi Fracture** – Fracture of the distal radius with dislocation of the **distal radioulnar joint**.
- **Monteggia Fracture** – Fracture of the **proximal ulna** with dislocation of the **radial head**.
- **Bennett's Fracture** – **Intra-articular fracture of the base of the first metacarpal**.

- **Boxer's Fracture** – Fracture of the **5th metacarpal neck**, common in punching injuries.
- **Pott's Fracture** – **Bimalleolar ankle fracture**.
- **Hangman's Fracture** – Fracture of the **C2 vertebra**, sustained in **hyperextension injuries**.

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## 8. Pathological Fractures

A fracture is termed **pathological** when it occurs in a **bone weakened by an underlying disease**.

### Common Causes of Pathological Fractures

### (a) Localized Diseases

- **Osteomyelitis** (chronic bone infection).
- **Benign tumors** (giant cell tumor, enchondroma).
- **Malignant bone tumors** (osteosarcoma, Ewing's sarcoma).

### (b) Generalized Diseases

- **Osteoporosis** – Most common cause in the elderly.
- **Osteomalacia and rickets** – Defective bone mineralization.
- **Paget's disease** – Bone remodeling disorder.
- **Metastatic carcinoma** – Secondary spread from **lung, prostate, breast, kidney cancers**.

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## Diagnosis of Fractures

- **History and Clinical Examination** – Mechanism of injury, pain, swelling, deformity.
- **X-ray** – Gold standard for fracture diagnosis.
- **CT Scan** – Used for **complex fractures** (e.g., pelvic fractures).
- **MRI** – Identifies **soft tissue injuries, stress fractures, and bone marrow edema**.

▼ Open fractures- clinical features, classification, investigations and treatment of open fractures

## Introduction

An open fracture (compound fracture) is a break in the bone where the overlying skin and soft tissues are disrupted, leading to communication between the fracture site and the external environment. This exposure increases the risk of infection, non-union, and delayed healing. Open fractures require immediate attention, aggressive management, and a multidisciplinary approach to prevent complications.

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## Clinical Features of Open Fractures

### 1. Symptoms

- **Severe pain** at the fracture site.
- **Visible wound with exposed bone fragments**.
- **Bleeding and swelling** around the injury site.
- **Difficulty in limb movement** or complete loss of function.

### 2. Signs

- **Wound with bone exposure** – Varies in size and severity.
- **Crepitus** – Grating sensation due to bone fragments.
- **Deformity of the limb** – Misalignment or angulation.
- **Neurovascular injury** – Absent distal pulses, loss of sensation, or weakness.
- **Soft tissue damage** – Skin, muscle, tendon, and ligament involvement.

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## Classification of Open Fractures

Several classification systems exist to categorize open fractures based on **severity, wound contamination, and soft tissue involvement**.

### 1. Gustilo-Anderson Classification (Most Commonly Used)

#### Type I

- Wound size **<1 cm**, minimal contamination.
- Simple fracture pattern with minimal soft tissue damage.

#### Type II

- Wound size **>1 cm but <10 cm**, **moderate contamination**.
- No significant soft tissue loss, simple or mildly comminuted fracture.

#### Type III (Severe Open Fractures, Further Divided into A, B, C)

- **Type IIIA** – Extensive **soft tissue damage**, adequate coverage over bone.
- **Type IIIB** – Extensive **soft tissue loss**, periosteal stripping, requires **flap coverage**.
- **Type IIIC** – **Vascular injury** requiring **repair**, often associated with high risk of amputation.

### 2. Tscherne Classification (Soft Tissue Injury-Based)

- **Grade 1**: Minor soft tissue injury.
- **Grade 2**: Deep abrasion, moderate muscle damage.
- **Grade 3**: Extensive muscle crushing, neurovascular injury.
- **Grade 4**: Total or subtotal limb amputation.

### 3. AO/OTA Classification

- Based on **fracture pattern, soft tissue damage, and neurovascular involvement**.

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## Investigations for Open Fractures

### 1. Radiological Investigations

**X-ray (Primary Investigation)**

- Determines **fracture type, displacement, and alignment**.

- Must include **two views (AP and Lateral)**.

**CT Scan**

- Used for **complex fractures (pelvis, spine, intra-articular injuries)**.

**MRI**

- Assesses **soft tissue and ligamentous injuries**.

**Angiography (If Vascular Injury Suspected)**

- Required for **Type IIIC open fractures with absent pulses**.

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### 2. Laboratory Investigations

**Complete Blood Count (CBC)** – Evaluates **blood loss, infection risk**.

**Coagulation Profile** – Important in **patients on anticoagulants**.

**C-Reactive Protein (CRP), ESR** – Markers for **infection and inflammation**.

**Blood Culture** – If **sepsis is suspected**.

**Wound Swab for Culture and Sensitivity** – Identifies **infecting organisms**.

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## Treatment of Open Fractures

### Phase I: Emergency Care (Pre-Hospital & Initial Management)

1. **Assess ABCs (Airway, Breathing, Circulation) – Trauma Resuscitation**.
2. **Control Bleeding** – Apply **direct pressure with sterile dressing**.
3. **Immobilization** – Use **splints or temporary fixation**.
4. **Pain Management** – **IV analgesics (NSAIDs, opioids)**.
5. **Tetanus Prophylaxis** – Given if vaccination status is uncertain.
6. **Start IV Antibiotics**
    - **Type I & II:** 1st-generation cephalosporin (**Cefazolin**).
    - **Type III:** Cephalosporin + Aminoglycoside (**Gentamicin**).
    - **Heavily contaminated wounds:** Add **Metronidazole** for anaerobic coverage.

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## Phase II: Definitive Surgical Treatment

The goal is to **achieve bone stability, prevent infection, and promote healing**.

### 1. Wound Debridement

- **Removes necrotic tissue, foreign bodies, and devitalized bone**.
- **Irrigation with saline (3–9L) and antiseptic solution**.
- Performed **within 6 hours ("golden period")**.

### 2. Fracture Stabilization

**External Fixation** – Preferred in **severely contaminated fractures, polytrauma**.

**Internal Fixation (ORIF - Open Reduction Internal Fixation)** – Used for **clean open fractures with good soft tissue coverage**.

**Skeletal Traction** – Used for **temporary stabilization in large fractures**.

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## Phase III: Wound Closure & Reconstruction

- **Primary Closure** – Only if wound is **clean and minimal contamination**.
- **Delayed Primary Closure (DPC)** – Performed **after 3-5 days** if there is no infection.
- **Flap Coverage (For Type IIIB & IIIC)** – Free flaps, muscle grafts (e.g., Latissimus dorsi, gastrocnemius flap).

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## Phase IV: Rehabilitation

- **Early Mobilization** – To **prevent stiffness and muscle wasting**.
- **Weight Bearing** – Started **gradually as per fracture healing**.
- **Physiotherapy** – Strengthens **muscles, improves joint movement**.

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# Complications of Open Fractures

### 1. Early Complications

- **Infection (Osteomyelitis, Sepsis)**.

- **Neurovascular injury** – Can cause **ischemia, limb loss**.
- **Fat embolism syndrome** – Seen in **long bone fractures**.
- **Compartment syndrome** – Increased pressure leading to **ischemia and necrosis**.

## 2. Late Complications

- **Non-Union & Malunion** – Poor healing due to **soft tissue loss**.
- **Chronic osteomyelitis** – Persistent **bone infection**.
- **Joint stiffness and contractures**.

▼ Compound fracture

## Introduction

A compound fracture, also known as an open fracture, is a type of fracture where the broken bone communicates with the external environment due to a break in the overlying skin and soft tissues. This exposure increases the risk of infection, delayed healing, and soft tissue complications. Compound fractures are considered orthopedic emergencies and require immediate management to prevent complications such as osteomyelitis, sepsis, and non-union.

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## Clinical Features of Compound Fractures

### 1. Symptoms

- **Severe pain at the fracture site**.
- **Visible wound with exposed bone fragments**.
- **Bleeding from the injury site**.
- **Swelling and bruising around the fracture**.
- **Difficulty or inability to move the affected limb**.

### 2. Signs

- **Open wound with bone protrusion** – Varies from a small puncture wound to a large soft tissue defect.
- **Gross deformity of the limb** – Malalignment, shortening, or angulation.
- **Crepitus** – Grating sensation from bone fragments moving against each other.
- **Neurovascular compromise** – Absent pulses, cold limb, loss of sensation.
- **Soft tissue damage** – Skin, muscle, tendons, and neurovascular structures may be affected.

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## Classification of Compound Fractures

### 1. Gustilo-Anderson Classification

This is the most widely used system to classify **open fractures based on wound size, soft tissue involvement, and contamination level**.

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- Simple fracture with minimal soft tissue damage.

### Type II

- Wound size **>1 cm but <10 cm**, **moderate soft tissue damage**.
- No significant periosteal stripping.

### Type III (Severe Open Fractures)

- **Type IIIA** – Extensive **soft tissue damage**, but with adequate coverage of the bone.
- **Type IIIB** – **Severe soft tissue loss**, periosteal stripping, requires **flap coverage**.
- **Type IIIC** – **Associated vascular injury**, requiring **vascular repair**, high risk of amputation.

### 2. AO/OTA Classification

- Based on **fracture pattern, extent of soft tissue damage, and involvement of neurovascular structures**.

### 3. Tscherne Classification

- Focuses on **soft tissue injury severity**, ranging from **Grade 1 (minor injury)** to **Grade 4 (severe injury with amputation risk)**.

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## Investigations for Compound Fractures

### 1. Radiological Investigations

**X-ray (Primary Investigation)**

- Essential to determine **fracture type, displacement, and bone alignment**.
- Must include **AP and lateral views**.

**CT Scan**

- Useful for **complex fractures (pelvic, intra-articular, comminuted fractures)**.

**MRI**

- Assesses **soft tissue and ligamentous injuries**.

**Angiography (If Vascular Injury Suspected)**

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# Complications of Compound Fractures

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- **Compartment syndrome** – Increased pressure leading to **ischemia and necrosis**.

## 2. Late Complications

- **Non-Union & Malunion** – Poor healing due to **soft tissue loss**.
- **Chronic osteomyelitis** – Persistent **bone infection**.
- **Joint stiffness and contractures**.

▼ Stress fractures

## Introduction

A stress fracture is a small crack or severe bruising within a bone, caused by repetitive mechanical stress rather than a single traumatic event. It is commonly seen in athletes, military personnel, and individuals with sudden increases in physical activity. Unlike traumatic fractures, stress fractures develop gradually over time due to repetitive loading.

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## Etiology and Risk Factors

- **Overuse and repetitive stress** – Running, jumping, prolonged marching.
- **Sudden increase in activity** – Change in training intensity or surface.
- **Biomechanical factors** – Flat feet, high arches, improper footwear.
- **Nutritional deficiencies** – Calcium, Vitamin D deficiency, low energy availability.
- **Osteoporosis or metabolic bone disease** – Increased bone fragility.
- **Female athlete triad** – Disordered eating, amenorrhea, low bone density.

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## Common Sites of Stress Fractures

- **Lower limb (most common)** – Tibia, metatarsals (March fracture), femoral neck.
- **Foot and ankle** – Navicular bone, calcaneus.
- **Pelvis** – Pubic rami, sacrum.
- **Spine** – Pars interarticularis (spondylolysis).

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## Clinical Features

- **Gradual onset of localized pain** – Initially mild, worsening with activity.
- **Pain relieved by rest** but worsens with weight-bearing activities.
- **Tenderness over the fracture site** with minimal swelling.

- **Absence of bruising or gross deformity**, unlike traumatic fractures.

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# Investigations

## 1. Imaging Studies

**X-ray (First-line)** – Often normal initially; visible fractures appear after 2-3 weeks.

**MRI (Gold Standard)** – Detects early bone marrow edema.

**Bone Scintigraphy** – Identifies areas of increased bone turnover.

**CT Scan** – Used for **complex anatomical sites** (e.g., navicular, femoral neck).

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# Treatment

## Non-Surgical Management (Most Cases)

- **Activity modification** – Rest from high-impact activities for 6-8 weeks.
- **Immobilization** – Walking boot or cast for severe cases.
- **Pain management** – NSAIDs (use with caution as they may delay healing).
- **Nutritional optimization** – Ensure adequate **calcium and Vitamin D intake**.

## Surgical Management (For High-Risk Fractures)

- **Indications** – Femoral neck fractures, navicular fractures, persistent non-union.
- **Internal fixation with screws** to stabilize the bone and accelerate healing.

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# Prevention

- **Gradual increase in physical activity** to allow bone adaptation.
- **Proper footwear** with adequate arch support.
- **Cross-training** to reduce repetitive impact.
- **Strength training and flexibility exercises** to improve biomechanics.

# 2. Anatomy of Bone and Fracture Healing

▼ Stages(pathology) of fracture healing of cortical bone, factors influencing it and complications of fractures

## Introduction

Fracture healing is a complex biological and mechanical process that restores the bone's structural and functional integrity. Unlike soft tissue healing, bone healing results in the regeneration of mineralized mesenchymal tissue rather than scar formation. The process follows distinct stages, influenced by multiple systemic and local factors. If these factors are unfavorable, it can lead to complications such as delayed healing, non-union, or malunion.

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## Stages of Fracture Healing (Frost, 1989)

Fracture healing occurs in **five continuous and overlapping stages**:

### 1. Stage of Hematoma Formation (Less than 7 days)

- Immediately after a fracture, **blood leaks** from torn vessels and accumulates around the fracture ends, forming a **hematoma**.
- The **periosteum and soft tissues are stripped**, leading to **ischemic necrosis of fracture ends**.
- The hematoma provides **inflammatory signals** to activate precursor cells for repair.

### 2. Stage of Granulation Tissue Formation (Up to 2-3 weeks)

- The **hematoma is invaded by fibroblasts, osteoblasts, and new blood vessels**.
- A **fibrovascular tissue (granulation tissue)** forms, bridging the fracture gap.
- This tissue **lacks mechanical strength** but serves as a **scaffold for new bone formation**.

### 3. Stage of Callus Formation (4-12 weeks)

- Osteoblasts differentiate and deposit **osteoid tissue**, which mineralizes to form a **soft callus (woven bone)**.
- The callus is **radiologically visible** and **clinically signifies fracture union**.

- Callus formation occurs **faster in children** and **slower in cortical bones than in cancellous bones**.

### 4. Stage of Remodeling (1-2 years)

- The woven bone is replaced by **mature lamellar bone**.
- The callus is remodeled by **osteoclasts and osteoblasts** to restore the original bone structure.
- This stage **realigns the bone and increases mechanical strength**.

### 5. Stage of Modeling (Many years)

- Final reshaping of the bone occurs to **restore its original contour**.
- The process is stimulated by **local mechanical stress and weight-bearing**.
- More prominent in **children** with angulated fractures.

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## Factors Influencing Fracture Healing

Several factors **positively or negatively** affect the rate and quality of bone healing.

### 1. Systemic Factors

### (a) Age of the Patient

- **Children** heal faster due to **higher osteoblastic activity**.
- **Elderly patients** have **slower healing due to osteoporosis**.

### (b) Nutritional Status

- **Calcium, Vitamin D, and protein deficiency** impair bone formation.
- **Malnourishment leads to weak callus formation**.

### (c) Endocrine and Metabolic Conditions

- **Hyperparathyroidism and diabetes** delay healing.
- **Growth hormone and thyroid hormones** promote fracture healing.

### (d) Medications

- **NSAIDs and corticosteroids** inhibit bone healing by reducing **prostaglandin-mediated repair**.
- **Bisphosphonates delay remodeling**, increasing the risk of atypical fractures.

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## 2. Local Factors

### (a) Type of Bone

- **Cancellous bones (e.g., vertebrae, ribs)** heal **faster** than cortical bones.
- **Long bones heal slower due to their dense structure**.

### (b) Fracture Pattern

- **Spiral fractures heal faster** due to a **larger contact surface for callus formation**.
- **Comminuted fractures heal slower** due to extensive soft tissue damage.

### (c) Vascularity of the Bone

- **Well-vascularized bones (e.g., ribs, flat bones)** heal rapidly.
- **Poorly vascularized bones (e.g., scaphoid, femoral head)** are prone to **avascular necrosis and delayed healing**.

### (d) Degree of Soft Tissue Injury

- **Severe periosteal stripping and muscle damage** delay healing.
- **Soft tissue interposition between fracture ends** prevents bone bridging.

### (e) Stability of the Fracture

- **Rigid fixation (internal or external)** promotes healing by preventing **excessive movement**.
- **Excessive mobility** delays bone bridging and leads to **non-union**.

### (f) Infection

- **Osteomyelitis and wound contamination** severely impair healing.

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# Complications of Fractures

Fractures can lead to **immediate, early, or late complications**.

## 1. Immediate Complications (At the Time of Injury)

- **Neurovascular Injury** – Nerve damage (e.g., radial nerve palsy in humerus fracture).
- **Hemorrhage and Shock** – Major fractures (pelvis, femur) can cause life-threatening bleeding.
- **Fat Embolism Syndrome** – Occurs in **long bone fractures**, leading to **respiratory distress and petechial rash**.

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## 2. Early Complications (Days to Weeks After Fracture)

- **Compartment Syndrome** – Increased pressure in muscle compartments leads to **ischemia and necrosis**.
- **Infection (Osteomyelitis)** – Common in **open fractures** and requires **aggressive debridement and antibiotics**.
- **DVT and Pulmonary Embolism** – Prolonged immobilization increases **venous thromboembolism risk**.

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## 3. Late Complications (Months to Years)

**Delayed Union**

- Fracture heals **slower than expected** but eventually consolidates.
- Causes: **Inadequate immobilization, poor blood supply, infection**.

**Non-Union**

- **Failure of bone healing beyond 6 months**.
- Types:
  - **Hypertrophic Non-Union** – Excess callus formation due to instability.
  - **Atrophic Non-Union** – No callus formation due to **poor blood supply**.
- **Management:** Bone grafting, internal fixation, electrical stimulation.

**Malunion**

- Healing in an **abnormal position**, causing **deformity or limb shortening**.
- Treated with **osteotomy and realignment surgery**.

**Avascular Necrosis (AVN)**

- **Death of bone tissue due to disrupted blood supply**.
- Common in **scaphoid, femoral head, talus fractures**.
- **MRI is the best diagnostic tool**.

**Post-Traumatic Arthritis**

- Occurs in **intra-articular fractures**, leading to **joint stiffness and chronic pain**.
- May require **joint replacement** in severe cases.

# 3. Treatment of Fractures: General Principles

▼ Plaster of paris

## Introduction

Plaster of Paris (POP) is a widely used immobilization material in orthopedic practice. It is composed of calcium sulfate hemihydrate ($CaSO_4 \cdot ½H_2O$), which, when mixed with water, undergoes an exothermic reaction, setting into a hard, rigid cast. POP is commonly used for fracture immobilization, correction of deformities, and postoperative stabilization. It provides structural support, pain relief, and fracture alignment during the healing process.

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## Composition and Chemistry

- **Chemical Formula**: **$CaSO_4 \cdot ½H_2O$ (Calcium sulfate hemihydrate)**.
- When mixed with water, it converts into **calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$)**, forming a **hard structure** as it dries.
- The **setting reaction is exothermic**, releasing **heat**, which **accelerates hardening**.

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## Indications for Plaster of Paris Use

1. **Fracture Immobilization** – Temporary or definitive casting for **stable fractures**.
2. **Post-Surgical Protection** – After **internal fixation or soft tissue repair**.
3. **Correction of Deformities** – Used in conditions like **clubfoot (Ponseti method)**.
4. **Traction and Splinting** – Applied in **skeletal traction for long bone fractures**.
5. **Orthopedic Bracing** – Support for conditions like **scoliosis, post-polio deformities**.

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## Types of POP Casts and Their Uses

POP can be applied in **different forms** depending on the fracture type and required immobilization.

| Type of Cast | Use |
|---|---|
| **Minerva Cast** | Cervical spine injuries |
| **Risser's Cast** | Scoliosis treatment |
| **Turn-Buckle Cast** | Scoliosis correction |
| **Shoulder Spica Cast** | Shoulder and humerus fractures |
| **U-Slab Cast** | Humeral shaft fractures |
| **Hanging Cast** | Midshaft humerus fractures |
| **Colles' Cast** | Distal radius fractures |
| **Hip Spica Cast** | Pediatric femur fractures |
| **Cylinder Cast** | Patellar and tibial fractures |
| **PTB Cast (Patellar Tendon Bearing Cast)** | Tibial fractures |

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# Application of Plaster of Paris Cast

## Step 1: Preparation

- Ensure **proper limb positioning**.
- Remove jewelry or tight clothing.
- Protect **bony prominences with padding** (e.g., cotton, foam).

## Step 2: Mixing and Application

- **Mix POP powder with water** in the correct ratio to form a smooth paste.
- Immerse POP bandages in water and **wring out excess liquid**.
- **Apply in layers**, molding to the limb for support.
- Ensure **joints are immobilized in a functional position**.

## Step 3: Drying and Setting

- The cast hardens **within 10-15 minutes**.
- Full strength is achieved in **24-48 hours**.
- Elevate the limb to **reduce swelling and improve comfort**.

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## Complications of POP Application

While POP is **widely used**, improper application can lead to **serious complications**.

### 1. Tight Cast Syndrome (Compartment Syndrome)

- Excessive pressure on soft tissues leads to **vascular compromise and ischemia**.
- Symptoms: **Severe pain, pallor, pulselessness, paresthesia, paralysis**.
- Treatment: **Immediate cast splitting or removal**.

### 2. Plaster Sores

- Poor padding or irregular cast surface causes **skin ulcers**.
- Prevented by **proper padding and smooth cast application**.

### 3. Thermal Burns

- The **exothermic setting reaction** can cause **burn injuries**.
- Prevented by **using cool water and applying thin layers**.

### 4. Joint Stiffness and Muscle Atrophy

- Prolonged immobilization leads to **joint contractures and muscle wasting**.
- Prevented by **early physiotherapy and range-of-motion exercises**.

### 5. Cast Breakage

- Weak areas in the cast can **lead to cracking**.
- Requires **reinforcement or reapplication**.

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## Advantages of POP Casts

- **Easily moldable** – Provides **customized immobilization**.
- **Cost-effective and widely available**.
- **Rapid setting and early immobilization**.
- **Good radiolucency** – X-rays can be taken without cast removal.

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## Disadvantages of POP Casts

- **Heavy and bulky** compared to fiberglass.
- **Weak in wet conditions** – Can **crack or soften** if exposed to water.
- **Exothermic reaction may cause burns**.
- **Longer drying time compared to modern synthetic casts**.

---

## Comparison: POP vs. Fiberglass Casts

| Feature | Plaster of Paris (POP) | Fiberglass Cast |
|---|---|---|
| **Material** | Calcium sulfate | Fiberglass resin |
| **Weight** | Heavier | Lighter |
| **Strength** | Weaker, brittle | Stronger, more durable |
| **Water Resistance** | Not water-resistant | Water-resistant |
| **Setting Time** | 24-48 hours | 1-2 hours |
| **Cost** | Cheaper | More expensive |

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## Care of a POP Cast

- **Keep dry** – Avoid water exposure as it weakens the cast.
- **Monitor for swelling or tightness** – Report **numbness or pain** immediately.
- **Do not insert objects inside the cast** – Prevents **skin irritation or ulceration**.
- **Follow weight-bearing instructions** – Avoid excessive strain on the cast.

▼ External fixation

# Introduction

External fixation is a stabilization technique used in the management of fractures, limb lengthening, and deformity correction. It involves the placement of percutaneous pins or wires into the bone, which are connected to an external frame to provide rigid immobilization. External fixators are widely used in open fractures, complex fractures, infected non-unions, and cases where internal fixation is not feasible.

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# Indications for External Fixation

1. **Severely Contaminated Open Fractures** – Particularly **Gustilo-Anderson Type IIIB and IIIC fractures**.
2. **Polytrauma Cases** – External fixation provides **rapid stabilization**, preventing further soft tissue damage and allowing **early mobilization**.
3. **Fractures with Severe Soft Tissue Injury** – Prevents **compartment syndrome and secondary ischemia**.
4. **Infected Non-Unions** – Used when **internal fixation is contraindicated** due to **infection risk**.
5. **Complex Intra-Articular Fractures** – Temporary fixation before definitive treatment.
6. **Limb Lengthening Procedures (Ilizarov Technique)** – For **correcting limb shortening and deformities**.
7. **Pediatric Fractures** – Where **internal fixation risks damage to growth plates**.

---

# Types of External Fixation

## 1. Pin Fixators (Unilateral or Monolateral)

- Consist of **percutaneous Schanz pins connected to an external bar**.
- Commonly used for **tibial fractures and upper limb fractures**.

### 2. Circular Ring Fixators (Ilizarov Frame)

- Uses **thin tensioned wires fixed to circular rings**.
- **Used in limb lengthening, deformity correction, and complex fractures**.

### 3. Hybrid Fixators

- **Combination of pin fixators and ring fixators**.
- Provides **greater stability** for **peri-articular fractures**.

### 4. Pelvic External Fixators

- Used for **unstable pelvic fractures** to **control bleeding and provide temporary stabilization**.

---

## Procedure for External Fixation

### 1. Preoperative Planning

- Assess **fracture pattern, soft tissue condition, and vascular integrity**.
- Choose appropriate **fixator type** based on **injury severity**.

### 2. Surgical Technique

- **Anesthesia** – General or regional anesthesia is used.
- **Pin Placement**
  - Pins are inserted into **safe zones** to avoid **neurovascular structures**.
  - **At least two pins per bone segment** to ensure **stability**.
- **Frame Assembly**
  - External rods or rings are connected to the pins.
  - The construct is adjusted to maintain **anatomical alignment**.
- **Tightening and Stabilization**
  - The frame is **locked** to prevent micromovement.

---

## Advantages of External Fixation

- **Minimally Invasive** – Preserves **soft tissue and periosteal blood supply**.
- **Immediate Fracture Stabilization** – Suitable for **polytrauma patients**.
- **Allows Soft Tissue Healing** – Prevents **excessive soft tissue disruption**.
- **Adjustable and Reversible** – Can be **modified without major surgery**.
- **Limb Lengthening and Deformity Correction** – **Ilizarov fixator allows gradual bone regeneration**.

---

## Disadvantages of External Fixation

- **Pin Tract Infections** – Requires **meticulous pin site care**.
- **Mechanical Discomfort** – External frame **limits movement** and may be bulky.
- **Delayed Union** – If used for **prolonged periods without proper bone stimulation**.
- **Risk of Joint Stiffness** – Particularly if used **near a joint for a long duration**.

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## Complications of External Fixation

### 1. Early Complications

- **Pin Tract Infections** – The most common complication, requiring **regular dressing and oral antibiotics**.
- **Neurovascular Injury** – Improper pin placement can damage **nerves and blood vessels**.
- **Compartment Syndrome** – Due to excessive swelling or improper pin placement.

### 2. Late Complications

- **Delayed Union or Non-Union** – Due to **inadequate stabilization**.
- **Joint Contractures** – Can occur if the fixator remains **in place for too long**.
- **Refracture After Removal** – Bone may **lose strength if the frame is removed too early**.

---

## Pin Site Care and Patient Management

- **Daily cleaning** with saline or antiseptic solution.
- **Monitoring for infection** (redness, pus, swelling).
- **Encouraging joint mobility and physiotherapy** to **prevent stiffness**.
- **Gradual weight-bearing** as guided by the surgeon.

▼ Thomas splint

## Introduction

The Thomas knee-bed splint (Thomas splint) is one of the most commonly used orthopedic splints. It was originally devised by H.O. Thomas for the immobilization of tuberculosis of the knee but is now widely used for hip, thigh, and lower limb fractures. It provides temporary stabilization and traction in patients with lower limb injuries, preventing further damage and reducing pain.

---

## Structure and Components

The **Thomas splint** consists of:

- **A ring** – Positioned around the groin.
- **Two sidebars** – Extend distally from the ring to the foot.
- **Distal joining bar** – Connects the two sidebars for stability.
- The ring is **angled at 120° to the inside bar**, and the **outer bar has a curvature** to accommodate the greater trochanter.

---

## Measurement of the Thomas Splint

- **Ring Size**: Determined by adding **2 inches to the thigh circumference** at the highest point of the groin.
- **Length**: Measured from the **groin (medial thigh) to the heel**, plus **6 inches** to allow for traction application.

---

## Uses of the Thomas Splint

- **Immobilization of lower limb fractures** (e.g., femur fractures).
- **Reduction of pain and soft tissue damage** in hip and thigh injuries.
- **Providing traction in fractures** requiring alignment.
- **Stabilization of patients with polytrauma** before definitive surgery.

---

## Care of a Patient in a Thomas Splint

1. The splint should be **properly applied with adequate padding** to protect bony prominences.
2. Bandaging must be **neither too tight nor too loose** to prevent sores or ineffective support.
3. The patient should be encouraged to **move joints within the splint** to prevent stiffness.
4. **Compression of nerves or vessels** due to tight bandaging must be detected early.
5. Regular **portable X-rays** should be taken to monitor fracture alignment and healing.

---

## Advantages of the Thomas Splint

- **Prevents further displacement of fractures**.
- **Reduces pain by minimizing movement**.
- **Allows for easier transportation of patients** with severe lower limb injuries.

# 4. Splints and Tractions

▼ Böhler-Braun splint

## Introduction

The Böhler-Braun splint is a frame-based orthopedic device used for immobilization and traction in lower limb fractures. It is designed to provide support, stability, and traction for fractures of the femur, tibia, and other lower limb injuries. Unlike the Thomas splint, it lacks a proximal ring, making it more comfortable, especially for elderly patients.

---

## Structure and Components

The **Böhler-Braun splint** consists of:

- **A rigid metal frame** with pulleys for applying traction.
- **Three adjustable bars** to provide varying degrees of traction.
- **A sling support system** for the affected limb.

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## Uses of Böhler-Braun Splint

- **Immobilization of lower limb fractures**, particularly tibial and femoral fractures.
- **Application of traction** using a system of pulleys to align the fracture.
- **Pain relief and prevention of further soft tissue injury**.
- **Temporary stabilization in polytrauma patients** before definitive surgery.

---

## Advantages of Böhler-Braun Splint

- **More comfortable than the Thomas splint** due to the absence of a proximal ring.
- **Allows for traction application** while keeping the limb in a supported position.
- **Prevents soft tissue damage** and helps in maintaining proper limb alignment.

---

## Care of a Patient in a Böhler-Braun Splint

1. Ensure **proper positioning and padding** to prevent pressure sores.
2. Regularly **monitor for signs of nerve compression or vascular compromise**.
3. Maintain **proper traction force** to avoid misalignment.
4. Encourage **joint movement in the unaffected areas** to prevent stiffness.
5. Perform **routine skin care and dressing changes** for long-term use.

▼ Skin traction

# Introduction

Skin traction is a non-invasive method of applying traction to a limb using adhesive or non-adhesive strapping attached to weights. It is commonly used for temporary fracture stabilization, pain relief, and soft tissue relaxation. Skin traction is preferred in children and elderly patients where skeletal traction may not be suitable.

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# Indications for Skin Traction

1. **Fracture Management** – Temporary stabilization of **femur, tibia, and hip fractures**.
2. **Joint Dislocations** – Used before **definitive treatment to maintain alignment**.
3. **Muscle Spasms and Pain Relief** – Helps in conditions like **hip arthritis, contractures**.
4. **Correction of Deformities** – Used in **pediatric cases for conditions like congenital hip dislocation**.

---

# Types of Skin Traction

## 1. Buck's Traction

- Most **commonly used for lower limb fractures**.
- Involves **adhesive strapping around the limb**, with weights applied at the foot end.
- Used in **hip fractures, femoral shaft fractures, and knee injuries**.

## 2. Russell's Traction

- Modification of Buck's traction, with a **sling under the knee** for additional support.
- Used for **fractures of the femur, tibia, and hip injuries**.

### 3. Bryant's Traction

- Used in **young children (<2 years old) with femoral fractures**.
- Both legs are **elevated at 90 degrees** to maintain alignment.

### 4. Gallow's Traction

- Used for **fractures of the femur in infants**.

---

## Application of Skin Traction

1. **The limb is cleaned and dried** to ensure **proper adhesion**.
2. **Adhesive or non-adhesive straps** are applied around the limb.
3. The **traction bandage is secured, and weights are attached**.
4. The leg is kept in a **neutral position**, with traction weights **hanging freely**.
5. **Regular monitoring** is done to ensure proper alignment and avoid complications.

---

## Advantages of Skin Traction

- **Non-invasive and easy to apply**.
- **Reduces pain and muscle spasms** in fractures.
- **Prevents further soft tissue damage**.
- **Safer for children** compared to skeletal traction.

---

## Disadvantages and Complications

- **Limited weight capacity** – Can only apply **3-4 kg**, making it unsuitable for unstable fractures.
- **Risk of skin injury** – **Blisters and ulcers** can develop due to prolonged use.
- **Ineffective in displaced fractures** – Skeletal traction may be required.
- **Nerve compression and circulatory impairment** – Tight bandages can cause **ischemia and nerve damage**.

## Care of a Patient in Skin Traction

1. **Ensure proper positioning** – The limb should be **elevated appropriately**.
2. **Check skin integrity** – Prevents **pressure sores and ulcers**.
3. **Monitor for neurovascular compromise** – Watch for **numbness, pallor, and pain**.
4. **Keep traction weights free-hanging** – Ensure they **do not touch the bed or floor**.
5. **Encourage passive limb movements** – Prevents **joint stiffness and muscle atrophy**.

▼ Skeletal traction

# Introduction

Skeletal traction is a method of **fracture stabilization** in which **metal pins or wires** are inserted **directly into the bone** and connected to weights that provide a constant pulling force. This technique is used to **maintain alignment, reduce fractures, and relieve pain**, particularly in **long bone fractures and complex injuries**.

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# Indications for Skeletal Traction

1. **Fractures of the Femur and Tibia** – Commonly used in **femoral shaft fractures** before surgery.
2. **Pelvic Fractures** – Helps in **stabilizing pelvic ring injuries**.
3. **Cervical Spine Injuries** – Used in **halo traction for cervical fractures**.
4. **Hip and Knee Dislocations** – Maintains alignment and prevents **further damage**.

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# Types of Skeletal Traction

## 1. Steinmann Pin Traction

- A **metal pin is drilled into the bone**, and traction is applied through **weights**.
- Used in **tibial and femoral fractures**.

## 2. Kirschner Wire (K-Wire) Traction

- Thin **metal wires** are inserted into the bone.
- Used in **smaller bones like the forearm or foot fractures**.

## 3. Halo Traction

- Used for **cervical spine fractures**.
- A **halo ring is attached to the skull**, providing immobilization.

### 4. Upper Tibial Pin Traction

- Used for **lower limb fractures**, such as **tibial and femoral fractures**.

---

## Application of Skeletal Traction

1. **A Steinmann pin or K-wire is inserted into the bone** under **sterile conditions**.
2. The **pin is secured with clamps**, and **weights are attached to provide traction**.
3. The patient's **limb is supported in a neutral position**, with weights **hanging freely**.
4. **Regular monitoring** is done to check for **infection, loosening of the pin, or pressure sores**.

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## Advantages of Skeletal Traction

- **Provides strong and stable traction** compared to skin traction.
- **Allows for controlled fracture alignment**.
- **Reduces muscle spasm and pain**.

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## Complications of Skeletal Traction

- **Pin tract infections** – Must be **cleaned regularly** to prevent osteomyelitis.
- **Neurovascular injury** – Improper pin placement may damage **nerves or blood vessels**.
- **Joint stiffness and muscle atrophy** – Prolonged immobilization may require **physiotherapy**.

---

## Care of a Patient in Skeletal Traction

1. **Ensure proper pin site care** to prevent infections.
2. **Check for neurovascular compromise** (pulses, sensation, and movement).
3. **Maintain proper weight alignment** to avoid displacement.

4. **Encourage limb mobilization and muscle exercises** to prevent stiffness.

# 5. Recent Advances in the Treatment of Fractures

▼ Fracture disease

## Introduction

Fracture disease refers to a series of complications that arise after a fracture due to prolonged immobilization. It is characterized by joint stiffness, muscle atrophy, osteoporosis, and pain. This condition results from prolonged immobilization, inadequate rehabilitation, or improper fracture management.

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## Pathophysiology of Fracture Disease

When a fracture occurs, **healing takes place in stages**, and immobilization is often required to stabilize the bone. However, **prolonged immobilization** leads to several complications:

1. **Joint stiffness** – Due to **lack of movement** and adhesions within the joint capsule.
2. **Muscle atrophy** – **Disuse of muscles** around the fractured limb leads to loss of muscle mass and weakness.
3. **Osteoporosis** – Prolonged immobilization results in **bone resorption**, making the bone weak and prone to fractures.
4. **Pain and swelling** – **Fibrosis, joint contractures, and vascular stasis** contribute to pain.
5. **Circulatory disturbances** – **Venous stasis and reduced blood flow** can lead to complications like **deep vein thrombosis (DVT)**.

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## Clinical Features

Fracture disease manifests as:

1. **Severe joint stiffness** – The patient experiences **reduced range of motion** due to joint adhesions.
2. **Muscle wasting** – The affected limb appears **thin and weak** due to muscle atrophy.
3. **Osteoporosis** – X-rays show **decreased bone density** in the immobilized limb.

4. **Pain and swelling** – Persistent **pain, swelling, and discomfort** even after fracture healing.
5. **Loss of function** – Patients **struggle with mobility and weight-bearing** activities.

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## Stages of Fracture Disease

Fracture disease progresses through three main stages:

1. **Stage of Acute Swelling**
   - Occurs **immediately after the fracture**.
   - **Inflammatory response leads to pain and swelling**.
   - **Immobilization begins**, which can contribute to circulatory stasis.
2. **Stage of Stiffness and Atrophy**
   - **Joint stiffness and muscle wasting develop** due to prolonged disuse.
   - **Loss of movement results in fibrosis and adhesion formation** within the joint capsule.
   - **Osteoporosis sets in**, making the bones brittle.
3. **Stage of Recovery or Deformity**
   - If properly rehabilitated, **gradual recovery of joint mobility and muscle strength occurs**.
   - If untreated, **permanent stiffness, contractures, and deformity** may result.

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## Prevention of Fracture Disease

Early **mobilization and physiotherapy** are key in preventing fracture disease. The following measures are recommended:

1. **Early Joint Mobilization**
   - **Passive and active movements should be initiated as early as possible**.
   - Use of **continuous passive motion (CPM) machines** can prevent stiffness.

2. **Muscle Strengthening Exercises**
    - **Isometric exercises** can be performed even with immobilization.
    - Once the cast is removed, **resistance exercises** should be started.
3. **Functional Bracing**
    - Helps to maintain **support and alignment while allowing movement**.
4. **Weight-Bearing Activities**
    - **Gradual weight-bearing** helps to **prevent osteoporosis**.
5. **Proper Immobilization Techniques**
    - Avoid prolonged **rigid immobilization**, which increases the risk of fracture disease.

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## Treatment of Fracture Disease

If fracture disease develops, the following treatment measures are taken:

1. **Physiotherapy and Rehabilitation**
    - **Gradual mobilization of the joint** using **passive, active-assisted, and active exercises**.
    - **Hydrotherapy (water-based exercises)** can aid in recovery.
2. **Pain Management**
    - **Analgesics and anti-inflammatory medications** to relieve pain.
    - **Hot fomentation and massage therapy** for muscle relaxation.
3. **Surgical Interventions**
    - **Arthrolysis (surgical removal of adhesions)** may be needed for severe contractures.
    - **Joint replacement surgery** in cases of permanent joint stiffness.

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## Complications of Fracture Disease

If untreated, fracture disease can lead to:

1. **Permanent joint stiffness and deformity** – Loss of normal joint function.

2. **Chronic pain and disability** – Due to fibrosis and muscle weakness.
3. **Pathological fractures** – Weak osteoporotic bones become prone to fractures.
4. **DVT and circulatory problems** – Due to prolonged immobilization.

▼ Splinting

# Introduction

Splinting is a method of immobilizing a fractured or injured limb to prevent further damage, reduce pain, and promote healing. Splints provide temporary stabilization before definitive treatment or are used as definitive immobilization for minor fractures, soft tissue injuries, and deformities.

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# Objectives of Splinting

1. **To immobilize fractures and dislocations** – Prevents further damage and maintains alignment.
2. **To reduce pain and muscle spasms** – Limits movement at the injury site.
3. **To allow soft tissue healing** – Provides support without excessive compression.
4. **To prevent neurovascular complications** – Avoids worsening of injuries.

---

# Types of Splints and Their Uses

Splints are classified based on their **design, function, and site of application**.

## 1. Common Orthopedic Splints

| Splint Name | Use |
|---|---|
| **Cramer-Wire Splint** | Temporary immobilization during transport |
| **Thomas Splint** | Femur fractures |
| **Böhler-Braun Splint** | Femur fractures with traction |
| **Aluminum Splint** | Finger immobilization |
| **Dennis Brown Splint** | Clubfoot (CTEV) |
| **Cock-Up Splint** | Radial nerve palsy |
| **Knuckle-Bender Splint** | Ulnar nerve palsy |
| **Toe-Raising Splint** | Foot drop |
| **Volkmann's Splint** | Ischemic contracture |
| **Four-Post Collar** | Neck immobilization |
| **Taylor's Brace** | Dorso-lumbar support |
| **Milwaukee Brace** | Scoliosis correction |
| **Boston Brace** | Scoliosis correction |

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# Methods of Splinting Fractures

Splinting techniques depend on the **fracture location and type**.

## 1. Intra-Medullary Splinting

- Used for **long bone fractures** such as the **femur or tibia**.
- A **long hollow rod (nail)** is inserted into the **medullary cavity** to stabilize the bone.
- Provides **rigid internal fixation**.

## 2. Extra-Medullary Splinting

- A **metal plate is applied to the bone surface**.

- Used in **humerus, tibia, or clavicle fractures**.
- Functions as a **neutralization plate** to prevent displacement.

### 3. Buttress Plating

- Used in **articular fractures**, such as **tibial plateau fractures**.
- The plate **supports and prevents collapse** of the fracture fragments.

### 4. External Splinting (External Fixator)

- Pins or screws are inserted **through the skin into the bone** and connected to an external frame.
- Used in **open fractures, infected fractures, and polytrauma patients**.

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## Combination of Compression and Splinting

- Some fractures, like **spiral fractures of the femur**, require **inter-fragmentary compression** using screws **in combination with splinting** by a neutralization plate.
- This ensures **rigid stability** and **faster healing**.

---

## Modern Splinting Concepts

- **Earlier, rigid fixation was preferred**, but it often compromised **bone blood supply**.
- **Modern AO concepts focus on "stable fixation" rather than absolute rigidity**, allowing **controlled movement** for improved healing.
- The use of **biological fixation techniques like bridge plating and functional bracing** is now widely accepted.

---

## Care of a Patient in a Splint

1. Ensure the **splint is properly applied** with adequate padding.
2. **Avoid excessive tightness**, which can cause pressure sores.

3. **Encourage muscle movement** within the splint to prevent stiffness.
4. **Regularly check for nerve or vascular compression** (pain, pallor, numbness).
5. **Monitor alignment with periodic X-rays**.

---

### Advantages of Splinting

- **Prevents further soft tissue damage**.
- **Reduces pain by limiting movement**.
- **Provides temporary or definitive stabilization**.
- **Allows for swelling without excessive constriction**.

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### Disadvantages and Complications

- **Improper splinting can cause pressure sores**.
- **Too tight splints can lead to neurovascular compromise**.
- **If not properly monitored, misalignment may persist**.

## 6. Approach to a Patient with Limb Injury

## 7. Complications of Fractures

▼ Non union- Definition, etiology, pathophysiology, investigations, treatment

## Overview

Non-union is a failure of fracture healing where the bone does not unite within the expected timeframe and lacks the biological potential to heal without intervention. It is typically diagnosed 6 to 9 months after the fracture, when there is no radiological evidence of callus formation or bridging across the fracture site.

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# Definition of Non-Union

A fracture is considered a **non-union** when it **fails to heal even after the expected duration** despite appropriate treatment. The fracture site shows **no progression of healing on serial radiographs**, and **fibrous tissue or pseudarthrosis** may form instead of new bone.

### Types of Non-Union

Non-union is classified into two main types based on callus formation:

1. **Atrophic Non-Union**
    - **Minimal or no callus formation** at the fracture site.
    - Occurs due to **lack of biological activity**, often seen in **vascular compromised fractures**.
    - Common in sites with **poor blood supply** (e.g., tibia, scaphoid).
2. **Hypertrophic Non-Union**
    - **Excess callus formation** is present, but the fracture ends fail to bridge.
    - Occurs due to **inadequate stability** despite sufficient blood supply.
    - Common in weight-bearing bones like **femur and tibia**.

---

# Etiology of Non-Union

Non-union can result from **multiple factors** related to the patient, the fracture, and treatment methods.

### 1. Patient-Related Factors

- **Older Age** – Bone healing potential decreases with age.
- **Smoking & Alcoholism** – Impairs vascularity and osteoblast function.
- **Diabetes & Osteoporosis** – Leads to poor bone remodeling.
- **Chronic Infections (e.g., Osteomyelitis)** – Disrupts the healing process.

### 2. Fracture-Related Factors

- **Severe Displacement** – Large gaps between fracture ends impair healing.
- **Comminuted or Open Fractures** – High-energy injuries have higher non-union rates.
- **Intra-articular Fractures** – Poor cartilage healing leads to instability.
- **Avascular Necrosis** – Bone fragments may lose blood supply (e.g., femoral head, scaphoid).

### 3. Treatment-Related Factors

- **Inadequate Immobilization** – Excessive motion at fracture site prevents callus formation.
- **Improper Surgical Fixation** – Rigid plating without biological fixation may impair healing.
- **Early Weight Bearing** – Excessive stress on the fracture disrupts healing.
- **Poor Surgical Technique** – Damage to periosteum and vascularity leads to non-union.

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## Pathophysiology of Non-Union

Normal bone healing occurs in **three stages** – **inflammatory, reparative, and remodeling phases**. Non-union occurs when this process is disrupted:

1. **Disruption of Blood Supply**
    - Leads to **ischemia and osteonecrosis** of the fracture ends.
    - Seen in **high-energy fractures, open fractures, and periosteal stripping**.

2. **Inadequate Stability**
    - Excess motion at the fracture site prevents **microvascular bridging** and bone formation.
    - Leads to **hypertrophic non-union** with excessive callus but no bridging.
3. **Failure of Cellular Activity**
    - Osteoblasts fail to proliferate, leading to **fibrosis at the fracture site** instead of new bone.
    - Occurs in **atrophic non-union**.
4. **Persistent Infection**
    - **Chronic osteomyelitis** can prevent healing by **destroying bone and soft tissues**.
    - Seen in **open fractures and post-operative infections**.

---

# Investigations for Non-Union

## 1. Clinical Assessment

- **Persistent pain and tenderness** at the fracture site.
- **Abnormal mobility or movement** (pseudarthrosis).
- **Swelling, deformity, or shortening** of the limb.

## 2. Radiological Investigations

- **X-ray (AP & Lateral View)**
    - Persistent **fracture line** with **no callus formation** in atrophic non-union.
    - Large callus with **no bridging** in hypertrophic non-union.
- **CT Scan**
    - **Best for assessing non-union and bone defects**.
    - Helps in **surgical planning**.

- **MRI Scan**
  - Used for **assessing soft tissue involvement and vascularity**.
  - Helps in detecting **infection and avascular necrosis**.
- **Bone Scintigraphy (Bone Scan)**
  - Differentiates between **viable (hypertrophic) and non-viable (atrophic) non-union**.
  - Useful in **chronic non-unions**.
- **Compartment Pressure Measurement**
  - Helps assess **compartment syndrome as a cause of non-union**.

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# Treatment of Non-Union

The treatment of non-union depends on the **type, severity, and underlying cause**.

## 1. Conservative Management (For Early Non-Unions)

- **Bone Stimulators (Electromagnetic/Ultrasound Therapy)** – Enhances osteoblastic activity.
- **Bracing & Immobilization** – May help in hypertrophic non-unions by limiting excessive motion.

## 2. Surgical Management

**a) Open Reduction and Internal Fixation (ORIF) with Bone Grafting**

- The **gold standard treatment** for non-union.
- **Bone grafts from the iliac crest or fibula** are used to promote healing.

**b) Excision of Non-Union Site**

- For **infected or atrophic non-unions**, excision of **necrotic bone and fibrous tissue** is done.

**c) Ilizarov Technique (Ring Fixator)**

- Used for **complex, infected, and segmental non-unions**.
- Provides **gradual distraction and compression** for bone healing.

**d) Plate Fixation with Bone Grafting**

- Used in **non-weight bearing long bones** (humerus, radius, ulna).

**e) Intramedullary Nailing**

- Preferred for **hypertrophic non-unions** of the **femur and tibia**.
- Provides **load-sharing stability** while allowing **biological bone healing**.

**f) Vascularized Bone Grafting**

- For **large segmental defects**, vascularized grafts (fibula or iliac crest) are used.

### 3. Treatment of Infected Non-Union

- **Debridement and removal of infected tissue**.
- **Antibiotic therapy based on culture sensitivity**.
- **Staged procedures** – External fixation first, followed by bone grafting.

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## Complications of Non-Union

- **Chronic pain and deformity**.
- **Shortening and limb dysfunction**.
- **Joint stiffness and arthritis**.
- **Pathological fractures**.
- **Persistent infection leading to osteomyelitis**.

▼ Malunion

## Overview

Malunion is a condition in which a fractured bone heals in an incorrect anatomical position, leading to deformity, functional impairment, or both. Malunion can result from inadequate reduction, improper immobilization, or premature weight-bearing, causing angulation, shortening, or rotational deformities at the fracture site.

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## Definition of Malunion

Malunion is defined as **a fracture that has healed with improper alignment**, leading to **functional or cosmetic deformity**. It may cause **pain, limited range of motion, gait abnormalities, or joint dysfunction** depending on the bone involved.

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## Etiology (Causes) of Malunion

Malunion can occur due to **several factors related to the patient, the fracture itself, or the treatment method**.

### 1. Patient-Related Factors

- **Lack of compliance** with immobilization or weight-bearing restrictions.
- **Severe soft tissue injury** affecting alignment and healing.
- **Delayed medical care** leading to improper fracture positioning.

### 2. Fracture-Related Factors

- **Comminuted fractures** – Small bone fragments may lead to displacement.
- **Intra-articular fractures** – Malunion of joint surfaces causes arthritis and functional loss.
- **High-energy trauma** – Involves significant bone and soft tissue damage, leading to healing defects.

### 3. Treatment-Related Factors

- **Inadequate reduction** – Poor realignment of the fracture during initial treatment.
- **Improper immobilization** – Poor splinting, casting, or unstable fixation leads to shifting of fragments.
- **Early removal of cast or hardware** – Can cause loss of reduction and improper healing.
- **Inadequate surgical technique** – Errors in **internal fixation, plating, or external fixation**.

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## Types of Malunion

Malunion is classified based on **the type of deformity** that results from improper healing.

### 1. Angular Malunion

- **Bone heals in a bent (angulated) position**.
- Can lead to **abnormal joint loading and arthritis** over time.

### 2. Rotational Malunion

- **Bone heals with abnormal rotation**, leading to **limb asymmetry and gait abnormalities**.
- Common in **femoral and tibial fractures**.

### 3. Translational Malunion

- **Bone fragments heal in an offset position** rather than in a straight line.
- Causes **altered weight distribution and biomechanical instability**.

### 4. Shortening Malunion

- **Bone heals in a shortened position**, leading to **limb length discrepancies**.
- Common in **long bone fractures (femur, tibia, humerus)**.

### 5. Malunion with Joint Deformity

- **Occurs in intra-articular fractures**, leading to **joint incongruity, stiffness, and arthritis**.

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## Clinical Features of Malunion

- **Visible deformity** – The affected limb may appear **crooked, twisted, or shortened**.
- **Pain and stiffness** – Especially in **weight-bearing bones and joints**.
- **Functional impairment** – Difficulty in **walking, gripping, or lifting** depending on the bone involved.
- **Gait abnormalities** – Seen in **lower limb malunions** due to limb length discrepancy.
- **Joint instability or arthritis** – In cases of **articular malunion**.

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## Investigations for Malunion

### 1. X-Ray (AP & Lateral Views)

- Confirms **angulation, rotation, or shortening** at the fracture site.
- Helps assess **joint involvement** in intra-articular malunions.

### 2. CT Scan

- Provides a **3D reconstruction** of the malunited bone.
- Essential for **complex deformities and surgical planning**.

### 3. MRI Scan

- Evaluates **soft tissue damage, ligament injury, or cartilage involvement**.
- Useful in **malunited intra-articular fractures**.

### 4. Limb Length Discrepancy Measurement

- Used for **shortening malunions**, often measured via **scanogram or full-length X-ray**.

### 5. Functional Assessment

- Evaluates **gait analysis, joint range of motion, and muscle strength**.

---

## Treatment of Malunion

The treatment of malunion depends on **severity, location, and functional impairment**. Minor malunions may not require intervention, while **severe deformities require corrective surgery**.

### 1. Non-Surgical Management

- **Mild malunions** that do not cause functional problems may **not require intervention**.
- **Shoe lifts or orthotics** – Used for **shortening <2 cm** in lower limb malunions.
- **Physiotherapy and bracing** – Helps improve function and minimize symptoms.

### 2. Surgical Management (Osteotomy & Realignment)

Surgical correction is indicated for **significant deformity, pain, or functional loss**.

### a) Corrective Osteotomy

- **Surgical fracture is created at the malunited site**, and the bone is realigned.
- Fixation is done using **plates, screws, or intramedullary nails**.

### b) Osteoclasis (Refracturing the Bone)

- Used in **children** to correct mild to moderate angular deformities.
- The **malunited bone is carefully rebroken** and immobilized in the correct position.

### c) Bone Grafting

- **Used in shortening malunions** to **restore bone length**.
- Common donor sites: **Iliac crest, fibula, or allografts**.

### d) Lengthening Procedures (Ilizarov Technique)

- Used for **severe shortening malunions** (>2 cm).
- The Ilizarov fixator provides **gradual distraction osteogenesis** to correct limb length.

### e) Joint Reconstruction (For Articular Malunion)

- **Arthroplasty (Joint Replacement)** – Used when malunion leads to **severe arthritis**.
- **Arthrodesis (Joint Fusion)** – Performed in **irreparable malunions** to improve stability.

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## Complications of Malunion

- **Chronic pain and arthritis** – Due to **poor joint alignment and abnormal weight-bearing**.
- **Gait abnormalities and difficulty walking** – Especially in lower limb malunions.
- **Nerve compression** – Malunited bones may press on nerves, causing **pain or numbness**.
- **Increased fracture risk** – Deformities may lead to **stress fractures in adjacent bones**.
- **Cosmetic deformity** – Leading to **psychological distress** in some patients.

▼ Myositis Ossificans

## Overview

Myositis ossificans is a heterotopic ossification disorder where bone forms within soft tissues, usually around joints or muscles. It commonly occurs following trauma, such as fractures or severe contusions, leading to restricted movement and joint stiffness.

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## Definition

Myositis ossificans refers to the **abnormal formation of bone tissue within muscle or soft tissue**, usually **after trauma or repeated mechanical stress**. The ossified mass can **restrict joint movement** and, in severe cases, cause **ankylosis** (complete loss of movement).

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## Etiology (Causes)

### 1. Traumatic Causes (Post-Traumatic Ossification)

- **Direct injury to muscle or joint** – Fractures, dislocations, or contusions.
- **Repetitive trauma or stress** – Common in **athletes and military recruits**.
- **Post-surgical complications** – Seen after **orthopedic surgeries (hip replacements, amputations, spinal injuries, etc.)**.

### 2. Neurological Causes

- **Head injury and spinal cord injury** – Increased risk due to **prolonged immobility and spasticity**.
- **Paraplegia** – Commonly affects **elbows, hips, and knees**.

### 3. Genetic and Idiopathic Causes

- **Fibrodysplasia ossificans progressiva (FOP)** – A rare genetic disorder causing **progressive ossification** of muscles and connective tissues.

### 4. Miscellaneous Causes

- **Deep tissue massage or aggressive physiotherapy** – Can trigger ossification after injury.
- **Burn injuries and infections** – Leading to localized inflammatory response and bone formation.

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## Pathophysiology

1. **Initial Trauma**
   - **Hematoma formation** occurs at the site of injury.
   - Macrophages and fibroblasts accumulate, triggering an **inflammatory response**.
2. **Osteogenic Differentiation**
   - The injured **periosteum and mesenchymal stem cells** differentiate into **osteoblasts** instead of normal muscle cells.
   - This leads to **abnormal bone formation within muscle tissue**.
3. **Progressive Ossification**
   - **Calcium deposition** occurs, leading to the formation of a **bony mass**.
   - The ossified mass **restricts joint mobility** and can cause **pain and stiffness**.
4. **Maturation**
   - Over time, the abnormal bone may **stabilize and remodel**.
   - In severe cases, it can **completely bridge the joint**, causing **ankylosis**.

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## Clinical Features

- **Localized pain and swelling** – Worsening over time rather than improving.
- **Joint stiffness and restricted movement** – Due to ossified mass near the joint.
- **Firm, palpable lump in muscle** – Develops gradually over weeks.
- **Skin redness and warmth** – Seen in early stages.
- **Progressive loss of function** – Especially in the **elbow, hip, and knee**.

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## Investigations

### 1. X-Ray

- **Early Stage** – Soft tissue swelling without calcification.
- **Late Stage** – **Fluffy calcifications** in the muscle mass.
- **Mature Stage** – **Well-defined bony mass** within soft tissue.

### 2. CT Scan

- Provides **detailed imaging of ossification** and helps differentiate **from tumors**.

### 3. MRI Scan

- **Detects early inflammatory changes** before bone formation occurs.

### 4. Bone Scan

- Shows **increased uptake** in the affected area, indicating **active bone formation**.

### 5. Biopsy (Rarely Needed)

- Performed if **malignancy is suspected** (differentiating from osteosarcoma).

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## Treatment of Myositis Ossificans

### 1. Conservative Management (Early Stage)

- **Rest and immobilization** – To prevent further soft tissue injury.
- **Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)** – Such as **indomethacin**, to reduce inflammation and inhibit ossification.
- **Cold compression** – Helps in reducing swelling and pain.

### 2. Avoiding Aggressive Physiotherapy

- **Massage and excessive stretching should be avoided**, as they can worsen ossification.

### 3. Surgical Management (For Severe Cases)

- **Excision of the bone mass** – Indicated when:
  - It **restricts movement** significantly.
  - It **compresses nerves or blood vessels**.
  - There is **persistent pain and dysfunction**.
- Surgery is performed **only after ossification has matured (6-12 months)** to prevent recurrence.

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## Complications

- **Joint contracture and ankylosis** – If the bone mass bridges the joint.
- **Persistent pain and stiffness**.
- **Compression of neurovascular structures**.
- **Recurrent ossification after surgery**.

▼ Compartment syndrome

## Overview

Compartment syndrome is a serious limb-threatening condition that occurs when increased pressure within a closed muscle compartment compromises blood flow and nerve function. If left untreated, it can lead to muscle necrosis, permanent disability, or even amputation.

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## Definition

Compartment syndrome is defined as **a condition in which increased pressure within a closed muscle compartment impairs blood supply, leading to tissue ischemia and necrosis**. It is an **orthopedic emergency** requiring **immediate intervention**.

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## Etiology (Causes of Compartment Syndrome)

Compartment syndrome is primarily caused by **any condition that increases pressure within a muscle compartment**, leading to **reduced perfusion and ischemia**.

### 1. Trauma-Related Causes

- **Fractures (most common)** – Tibia, femur, forearm fractures.
- **Crush injuries** – Road traffic accidents, industrial accidents.
- **Severe soft tissue injuries** – Contusions, muscle tears, gunshot wounds.
- **Burns and electrical injuries** – Cause **tissue swelling and eschar formation**, restricting expansion.

### 2. Post-Surgical Causes

- **Tight casts, splints, or dressings** – Prevent normal swelling, leading to pressure buildup.
- **Vascular injuries and hemorrhage** – Postoperative bleeding within a compartment.

### 3. Medical Conditions and Other Causes

- **Reperfusion injury** – After **prolonged ischemia**, sudden return of blood flow causes **swelling and increased pressure**.
- **Coagulopathies** – Increased risk of **bleeding into compartments**.
- **Intensive physical activity** – Excessive exercise (exertional compartment syndrome).

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## Pathophysiology of Compartment Syndrome

1. **Increased pressure within the compartment**
    - Trauma or internal bleeding leads to **fluid accumulation** inside the compartment.
    - Fascia surrounding the muscles is **non-expandable**, so pressure increases.
2. **Reduced blood supply (ischemia)**
    - **Capillary blood flow decreases** as pressure rises above **30-40 mmHg**.
    - Muscles and nerves become **deprived of oxygen and nutrients**.
3. **Cellular hypoxia and necrosis**
    - **Muscle and nerve cells die within 4-6 hours** if untreated.
    - Leads to **fibrosis, contractures, and loss of function**.
4. **Vicious Cycle of Pressure and Ischemia**
    - Ischemia triggers **histamine release and increased vascular permeability**

## 9. Fractures in Children

## 10. Peripheral Nerve Injuries

▼ Radial Nerve - Muscles Supplied and Wrist Drop: Etiology, Clinical Features, Investigations, and Treatment

## Overview

The radial nerve is a major peripheral nerve that arises from the posterior cord of the brachial plexus and is responsible for supplying motor and sensory functions to various muscles and skin regions of the upper limb. One of the most common clinical conditions associated with radial nerve dysfunction is **wrist drop**, which results from nerve injury leading to the inability to extend the wrist and fingers.

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## Muscles Supplied by the Radial Nerve

The radial nerve primarily supplies the extensor muscles of the upper limb. The innervation can be classified based on anatomical location:

### 1. Before the Radial Groove:

- Long and medial heads of triceps brachii

### 2. In the Radial Groove (Posterior Arm):

- Lateral head of triceps brachii
- Anconeus
- Brachioradialis
- Extensor carpi radialis longus

### 3. Below the Radial Groove (Forearm and Hand):

- Extensor carpi radialis brevis
- Supinator
- Extensor digitorum
- Extensor digiti minimi
- Extensor carpi ulnaris
- Abductor pollicis longus
- Extensor pollicis brevis

- Extensor pollicis longus
- Extensor indicis

Sensory supply includes the posterior arm, forearm, and dorsum of the lateral three and a half fingers, excluding the fingertips.

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## Wrist Drop: Etiology

Wrist drop, also known as **radial nerve palsy**, is caused by damage to the radial nerve, leading to paralysis of the extensor muscles of the wrist and fingers. The major causes include:

### 1. Traumatic Causes:

- **Humeral Shaft Fracture**: Midshaft fractures can injure the radial nerve in the spiral groove.
- **Crush Injury**: Direct trauma to the posterior arm may lead to nerve compression or transection.
- **Iatrogenic Injury**: Improper positioning during surgery or injections in the posterior arm.

### 2. Compression Causes:

- **Saturday Night Palsy**: Prolonged pressure on the radial nerve due to sleeping with the arm hanging over a chair.
- **Honeymoon Palsy**: Compression due to another person resting on the arm for extended periods.
- **Crutch Palsy**: Improper use of crutches leading to axillary nerve compression.

### 3. Neuropathic Causes:

- **Lead Poisoning**: Chronic lead exposure can cause peripheral neuropathy, including wrist drop.
- **Diabetic Neuropathy**: Affects multiple nerves, including the radial nerve.

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## Clinical Features of Wrist Drop

The key clinical manifestations of radial nerve palsy include:

- **Inability to extend the wrist and fingers at the MCP joints** (leading to the characteristic ‘wrist drop’ appearance).
- **Weakness in grip strength** due to inability to stabilize the wrist for finger flexors to act efficiently.
- **Sensory loss** in the dorsum of the hand and lateral three and a half fingers.
- **High Radial Nerve Palsy (Above Spiral Groove):** Involves triceps weakness along with wrist drop.
- **Low Radial Nerve Palsy (Below Spiral Groove):** Spares the triceps but causes wrist and finger drop.

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## Investigations

To confirm the diagnosis and assess the extent of nerve injury, the following investigations are recommended:

### 1. Clinical Examination:

- **Motor Testing:** Weakness of wrist and finger extension.
- **Tinel’s Sign:** Tapping over the nerve elicits tingling.
- **Electromyography (EMG):** Determines the extent of denervation.

### 2. Imaging Studies:

- **X-ray of Humerus:** To rule out fractures.
- **MRI:** For nerve compression or soft tissue pathology.

### 3. Nerve Conduction Studies:

- Measures the velocity of impulse conduction across the nerve.
- Helps differentiate between partial and complete nerve injuries.

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## Treatment of Wrist Drop

The management of radial nerve palsy depends on the severity of the injury:

### 1. Conservative Management (For Neuropraxia and Mild Injuries):

- **Splinting:** Cock-up splints to keep the wrist extended and prevent contractures.
- **Physiotherapy:** Strengthening exercises to improve muscle recovery.
- **Pain Management:** NSAIDs for symptomatic relief.
- **Observation:** Many cases recover spontaneously within 6–12 weeks.

## 2. Surgical Management (For Severe Cases):

- **Nerve Repair:** Primary repair if the nerve is completely transected.
- **Nerve Grafting:** If there is a large nerve gap.
- **Tendon Transfers:** For chronic cases, transferring functioning muscles to restore wrist extension.

▼ Foot Drop – Definition, Etiology, Clinical Features, Investigations, and Treatment

## Definition

Foot drop is a condition characterized by an inability to dorsiflex the foot, leading to difficulty in lifting the foot while walking. It results in a "steppage gait" where the patient compensates by lifting the knee higher than normal to prevent the foot from dragging.

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## Etiology

Foot drop results from dysfunction of the **common peroneal nerve** or **sciatic nerve** due to various causes, including:

1. **Neurological Causes**
   - Peripheral nerve injury (common peroneal nerve lesion at the fibular head)
   - Sciatic nerve injury
   - Lumbosacral radiculopathy (L4-L5 nerve root compression)
   - Stroke, multiple sclerosis, or motor neuron disease
2. **Traumatic Causes**
   - Direct trauma to the lateral aspect of the leg
   - Knee dislocation
   - Hip fracture or hip surgery leading to sciatic nerve injury
3. **Mechanical and Compressive Causes**
   - Prolonged leg crossing
   - Tight plaster casts or braces
   - External compression on the fibular neck (prolonged squatting, bedridden patients)
4. **Neuromuscular Disorders**
   - Charcot-Marie-Tooth disease
   - Guillain-Barré syndrome
   - Chronic inflammatory demyelinating polyneuropathy

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## Clinical Features

1. **Gait Abnormalities**
    - Patients exhibit a **high-stepping gait (steppage gait)** due to inability to dorsiflex the foot.
    - The **foot slaps on the ground** as the patient walks due to weak dorsiflexor muscles.
2. **Motor Weakness**
    - Weakness in dorsiflexion of the ankle (*tibialis anterior dysfunction*).
    - Weakness in eversion of the foot (*peroneus longus and peroneus brevis dysfunction*).
3. **Sensory Loss**
    - Numbness or tingling over the **anterolateral aspect of the lower leg and dorsum of the foot**, indicating **common peroneal nerve involvement**.
4. **Muscle Atrophy**
    - Chronic cases may show wasting of **anterior tibial and peroneal muscles**.
5. **Tests for Foot Drop**
    - **Toe Walk vs. Heel Walk**: Patients with foot drop are unable to walk on **heels** due to dorsiflexion weakness.
    - **Tinel's Sign**: Percussion over the fibular head may reproduce tingling in peroneal nerve injury.

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## Investigations

1. **Clinical Examination**
    - Motor function testing of **tibialis anterior, peroneus longus, and brevis muscles**.
    - Sensory testing over **the lateral shin and dorsum of the foot**.

2. **Electrodiagnostic Studies**
    - **Nerve Conduction Study (NCS)**: Helps localize the lesion and assess nerve function.
    - **Electromyography (EMG)**: Detects denervation changes in **tibialis anterior, extensor digitorum longus, and peroneal muscles**.
3. **Imaging**
    - **MRI of the lumbar spine**: To rule out L4-L5 radiculopathy.
    - **Ultrasound or MRI of the knee and leg**: To detect nerve entrapment or compression.

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## Treatment

1. **Conservative Management**
    - **Ankle-foot orthosis (AFO)**: Maintains foot dorsiflexion and prevents foot slapping.
    - **Physiotherapy**: Strengthens dorsiflexors and improves gait mechanics.
    - **Activity modification**: Avoid prolonged leg crossing and excessive pressure on the fibular head.
2. **Medical Treatment**
    - **Corticosteroids**: If inflammation or nerve entrapment is suspected.
    - **Neuropathic pain medications**: Gabapentin or pregabalin for associated pain.
3. **Surgical Treatment**
    - **Nerve decompression**: If peroneal nerve entrapment is confirmed.
    - **Tendon transfer surgery**: In chronic cases, **posterior tibial tendon transfer** can restore dorsiflexion.
    - **Nerve grafting**: If there is a complete peroneal nerve transection.

▼ Ulnar Claw Hand – Definition, Etiology, Clinical Features, Investigations, and Treatment

## Definition

Ulnar claw hand is a deformity resulting from **ulnar nerve dysfunction**, characterized by hyperextension of the metacarpophalangeal (MCP) joints and flexion of the interphalangeal (IP) joints of the **4th and 5th fingers**. It occurs due to **paralysis of the ulnar nerve-supplied intrinsic hand muscles**, leading to an imbalance between the extrinsic and intrinsic hand muscles.

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## Etiology

1. **Nerve Injury Causes**
    - **High ulnar nerve injury** (proximal to the elbow): Less prominent clawing due to loss of **flexor digitorum profundus (FDP)** function.
    - **Low ulnar nerve injury** (distal third of the forearm or at the wrist): More severe clawing as **FDP remains intact**, worsening the deformity.
2. **Trauma and Compression**
    - Fractures of the **medial epicondyle of the humerus**.
    - **Guyon's canal syndrome** (compression at the wrist).
    - Repetitive compression from prolonged use of crutches or bicycle handlebars (**Handlebar palsy**).
3. **Neurological Conditions**
    - Peripheral neuropathies (e.g., **diabetic neuropathy**).
    - **Leprosy** (common cause of ulnar nerve palsy in endemic regions).
4. **Tumors or Mass Lesions**
    - Ganglion cysts, lipomas, or tumors compressing the **ulnar nerve**.

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## Clinical Features

1. **Hand Deformity (Clawing of 4th and 5th Digits)**
    - **MCP joint hyperextension** due to unopposed action of extensor digitorum.
    - **IP joint flexion** due to loss of lumbricals, allowing flexor digitorum profundus (FDP) dominance.
    - More severe in **low ulnar nerve palsy** than high ulnar nerve palsy.
2. **Motor Weakness**
    - Weakness of **interossei muscles → inability to perform finger abduction and adduction (Froment's sign)**.
    - Weakness of **medial two lumbricals** → impaired flexion at MCP and extension at IP joints of the **4th and 5th fingers**.
    - Weak grip strength due to loss of **hypothenar muscles**.
3. **Sensory Loss**
    - Numbness and tingling over the **medial 1½ fingers (4th and 5th digits)** and **medial palm** in **ulnar nerve distribution**.
    - Loss of sensation over the **dorsal ulnar hand** if the injury is **proximal to the wrist**.
4. **Special Tests for Ulnar Nerve Dysfunction**
    - **Froment's Sign**: Patient is asked to hold a piece of paper between the thumb and index finger. If the **adductor pollicis (ulnar nerve) is weak**, the **flexor pollicis longus (median nerve) compensates**, causing thumb flexion.
    - **Egawa's Test**: Inability to **abduct and adduct the fingers** when the **hand is placed flat on a table**, indicating **interossei muscle weakness**.
    - **Card Test**: Patient is asked to **hold a card between the fingers** while the examiner tries to pull it away. Weak **palmar interossei muscles** indicate **ulnar nerve damage**.

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## Investigations

1. **Clinical Examination**
    - Assess motor function (**finger abduction, adduction, grip strength**).
    - Evaluate sensory loss in **ulnar nerve distribution**.

2. **Electrodiagnostic Studies**
    - **Nerve conduction study (NCS)**: Determines the site of nerve injury.
    - **Electromyography (EMG)**: Confirms denervation in **ulnar-innervated muscles**.
3. **Imaging**
    - **MRI or ultrasound** to detect nerve compression (e.g., Guyon's canal syndrome, tumors).
    - **X-ray** of the **elbow or wrist** to rule out fractures compressing the nerve.

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## Treatment

1. **Conservative Management**
    - **Splinting**:
        - **Anti-claw splint** (lumbrical bar splint) to **prevent MCP hyperextension**.
        - **Aeroplane splint** for high ulnar nerve palsy.
    - **Physiotherapy**:
        - Strengthening **intrinsic hand muscles** and maintaining range of motion.
        - Prevents contractures and maintains hand function.
    - **Avoid repetitive pressure**:
        - Avoid **prolonged elbow flexion or wrist compression** (e.g., cycling, using crutches).
2. **Medical Management**
    - **Neuropathic pain management**: Gabapentin, pregabalin, or NSAIDs.
    - **Steroid injections**: If nerve inflammation or compression is present (e.g., Guyon's canal syndrome).

3. **Surgical Management**
    - **Nerve decompression**: Indicated for compressive neuropathies (e.g., Guyon's canal release).
    - **Tendon transfers**:
        - **Zancolli lasso procedure** (transferring flexor tendons to correct MCP hyperextension).
        - **ECRL or FDS tendon transfer** to restore finger function in severe cases.
    - **Nerve grafting or repair**: If **nerve transection is confirmed**.

# 11. Deformities and their Management

# 12. Treatment of Orthopedic Disorders: General Review

▼ Osteotomy

**Definition:**

Osteotomy refers to the surgical cutting of a bone to correct deformities, improve function, or relieve pain. It is commonly performed in orthopedic procedures to realign bones, correct malalignment of joints, or address conditions such as arthritis and bone deformities.

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## Indications for Osteotomy:

Osteotomy is performed for various purposes, including:

1. **Correction of Deformities:**
    - Used to correct excessive angulation, bowing, or rotation of long bones.
    - Performed in cases of conditions like genu varum (bow-leggedness) or genu valgum (knock-knees).
2. **Joint Realignment:**
    - Helps in redistributing weight-bearing forces in cases of osteoarthritis.
    - Commonly performed for knee and hip osteoarthritis to delay the need for joint replacement.
3. **Leg Length Discrepancy:**
    - Osteotomy can help in lengthening or shortening a bone to correct limb length inequality.
4. **Trauma & Malunions:**
    - Used in cases where fractures heal improperly, leading to malunion requiring realignment.
5. **Special Indications:**
    - Some osteotomies are done for specific conditions, such as McMurray's osteotomy for fracture neck of the femur.

---

## Types of Osteotomies:

Osteotomies can be classified based on their purpose and technique:

1. **Angulation Osteotomy:**
    - Corrects bone angulation abnormalities.
    - Example: High tibial osteotomy for knee osteoarthritis.
2. **Displacement Osteotomy:**
    - Used to shift the bone to a new position for better function.
3. **Derotation Osteotomy:**
    - Performed to correct rotational deformities, such as femoral anteversion.
4. **Bone Shortening or Lengthening Osteotomy:**
    - Used in cases of limb length discrepancies.
    - Example: Ilizarov technique for limb lengthening.

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## Commonly Performed Osteotomies & Their Indications:

| Name of Osteotomy | Indication |
|---|---|
| McMurray's Osteotomy | Fracture neck of the femur |
| Pauwels' Osteotomy | Osteoarthritis of the hip |
| High Tibial Osteotomy | Osteoarthritis of the knee |
| French Osteotomy | Correction of cubitus varus deformity |
| Spinal Osteotomy | Ankylosing spondylitis |

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## Complications of Osteotomy:

1. **Non-union or Delayed Union:** Failure of bone healing at the osteotomy site.
2. **Infection:** Risk of osteomyelitis, especially in open procedures.
3. **Joint Stiffness:** Loss of mobility due to prolonged immobilization.
4. **Vascular or Nerve Injury:** Damage to nearby blood vessels and nerves during surgery.

5. **Recurrence of Deformity:** Inadequate correction may lead to a recurrence of the condition.

▼ Subtrochanteric Osteotomy

**Definition:**

Subtrochanteric osteotomy is a surgical procedure involving the controlled cutting and realignment of the femur just below the lesser trochanter. It is performed to correct deformities, improve joint mechanics, or redistribute weight-bearing forces in conditions affecting the hip.

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## Indications for Subtrochanteric Osteotomy:

1. **Correction of Hip Deformities:**
   - Used in conditions like congenital hip dysplasia and post-traumatic deformities.
   - Helps restore normal biomechanics and hip joint stability.
2. **Management of Osteoarthritis and Avascular Necrosis (AVN):**
   - Performed to delay the need for total hip replacement by altering weight distribution in the hip joint.
   - Beneficial in early stages of AVN by reducing stress on the femoral head.
3. **Post-Traumatic Malunion:**
   - Used to correct malaligned fractures of the proximal femur that lead to abnormal gait and function.
4. **Leg Length Discrepancy:**
   - Helps in cases where there is shortening of the affected limb due to femoral malalignment.
5. **Femoroacetabular Impingement (FAI):**
   - Used in cases where femoral deformities contribute to hip impingement and early arthritis.

---

## Types of Subtrochanteric Osteotomy:

1. **Varus Osteotomy:**
   - Used to reduce the load on the superior part of the femoral head.
   - Commonly performed in avascular necrosis of the femoral head.

2. **Valgus Osteotomy:**
    - Used to improve coverage of the femoral head by the acetabulum.
    - Helps in cases of developmental hip dysplasia.
3. **Rotational Osteotomy:**
    - Used to correct rotational deformities of the femur.
    - Beneficial in femoral anteversion or retroversion abnormalities.
4. **Derotation Osteotomy:**
    - Specifically designed to correct excessive femoral anteversion and improve alignment.

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## Surgical Technique:

1. **Preoperative Planning:**
    - X-rays and CT scans are used to assess the degree of deformity.
    - Appropriate osteotomy type and fixation method are selected.
2. **Surgical Steps:**
    - A lateral approach is commonly used to access the femur.
    - The subtrochanteric region is exposed, and the planned osteotomy is performed using an oscillating saw.
    - Bone realignment is done to achieve the desired correction.
    - Internal fixation is applied using plates, screws, or an intramedullary nail to stabilize the bone.
3. **Postoperative Care:**
    - Weight-bearing is restricted until signs of bone healing are evident.
    - Physical therapy is initiated to restore hip function and prevent stiffness.

---

## Complications of Subtrochanteric Osteotomy:

1. **Non-Union or Delayed Healing:**
    - Poor bone healing due to inadequate fixation or avascularity.

2. **Implant Failure:**
    - Breakage or loosening of plates or screws.
3. **Leg Length Discrepancy:**
    - Residual shortening or overcorrection may cause difficulty in walking.
4. **Infection:**
    - Risk of osteomyelitis if surgical site infection occurs.
5. **Vascular and Nerve Injury:**
    - Damage to surrounding neurovascular structures can lead to functional deficits.

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## Conclusion:

Subtrochanteric osteotomy is a valuable procedure for correcting hip deformities, managing avascular necrosis, and improving biomechanics in patients with hip pathology. Proper preoperative planning, precise surgical execution, and adequate postoperative rehabilitation are crucial for successful outcomes.

▼ Bone Grafting

**Definition:**

Bone grafting is a surgical procedure in which bone or bone-like material is transplanted to repair bone defects, enhance bone healing, or provide structural support. It is commonly used in cases of fractures, non-union, bone tumors, and spinal fusion surgeries.

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## Indications for Bone Grafting:

1. **Non-Union of Fractures:**
   - Used when fractures fail to heal due to poor vascularity or instability.
2. **Bone Defects:**
   - Filling bone voids caused by tumors, cysts, or trauma.
3. **Spinal Fusion:**
   - Used in procedures like scoliosis correction and spinal stabilization.
4. **Avascular Necrosis:**
   - Helps regenerate bone in early stages of avascular necrosis of the femoral head.
5. **Arthrodesis (Joint Fusion):**
   - Used to promote fusion in cases of severe arthritis where joint mobility is eliminated.
6. **Implant Fixation:**
   - Enhances stability in orthopedic and dental implants.

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## Types of Bone Grafts:

1. **Autografts (From the Same Person):**
    - **Cortical Bone Grafts:** Provide structural support, commonly harvested from the iliac crest, fibula, or ribs.
    - **Cancellous Bone Grafts:** Promote osteogenesis (bone formation) and are rich in bone marrow cells.
    - **Vascularized Bone Grafts:** Include attached blood supply, used in large bone defects or avascular necrosis.
2. **Allografts (From a Human Donor):**
    - **Fresh-Frozen Bone Grafts:** Stored in bone banks for later use.
    - **Demineralized Bone Matrix (DBM):** Processed to remove mineral content, leaving behind collagen and growth factors.
3. **Xenografts (From Another Species):**
    - Derived from bovine or coral sources, used mainly in dental procedures.
4. **Synthetic Bone Substitutes:**
    - **Hydroxyapatite and Calcium Phosphate:** Provide a scaffold for new bone growth.
    - **Bone Morphogenic Proteins (BMPs):** Stimulate bone formation without requiring graft material.

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## Surgical Technique for Bone Grafting:

1. **Preoperative Planning:**
    - Imaging studies (X-ray, CT scan) assess the extent of the bone defect.
    - Selection of graft type based on patient condition and graft site.
2. **Harvesting the Graft:**
    - In autografts, the graft is obtained from the iliac crest, fibula, or ribs.
    - Meticulous dissection is performed to minimize donor site morbidity.
3. **Graft Placement:**
    - The recipient site is prepared by removing non-viable tissue.
    - The graft is fixed using screws, plates, or other stabilizing devices.

4. **Closure and Postoperative Care:**
    - Soft tissue is closed over the graft to promote healing.
    - Weight-bearing is restricted, and rehabilitation is initiated.

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## Complications of Bone Grafting:

1. **Graft Resorption or Failure:**
    - Can occur if the graft does not integrate properly with the host bone.
2. **Infection:**
    - Particularly in allografts or large defect reconstructions.
3. **Donor Site Morbidity:**
    - Pain, hematoma, or fracture at the autograft harvest site.
4. **Graft Rejection:**
    - Rare in autografts but possible in allografts and xenografts.
5. **Non-Union or Delayed Union:**
    - Poor vascularization or improper fixation may delay healing.

▼ Tendon Transfers

**Definition:**

Tendon transfer is a surgical procedure in which the tendon of a functioning muscle is moved to a different site to restore lost movement due to nerve injury, muscle imbalance, or tendon rupture.

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## Indications for Tendon Transfers:

1. **Nerve Palsy:**
   - **Radial nerve palsy (Wrist drop):** Jone's transfer
   - **Ulnar nerve palsy (Claw hand):** Zancolli's lasso procedure
   - **Median nerve palsy (Ape hand):** Opponensplasty
2. **Muscle Imbalance:**
   - Conditions like cerebral palsy or polio where one group of muscles overpowers the other.
3. **Tendon Rupture:**
   - Chronic tendon injuries that cannot be repaired directly.

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## Principles of Tendon Transfer:

- **Donor tendon must have good strength (≥ 4/5 power).**
- **Range of motion of the donor should match the recipient.**
- **Minimal functional loss at the donor site.**

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## Common Tendon Transfers:

- **Jone's Transfer:** Used in radial nerve palsy to restore wrist and finger extension.
- **Froment's Sign Correction:** Transfer of flexor digitorum superficialis to restore thumb adduction in ulnar nerve palsy.
- **Split Anterior Tibial Tendon Transfer (SPLATT):** Used for correcting foot drop.

# 13. Injuries around Shoulder and Fracture

▼ Shoulder Injury and Anterior Shoulder Dislocation

### Overview

The shoulder joint is the most mobile joint in the human body but also the most commonly dislocated. Anterior shoulder dislocation is the most frequent type, accounting for nearly 95% of all shoulder dislocations. It often occurs due to indirect trauma, typically from a fall on an outstretched hand or direct impact.

## Classification

Shoulder dislocations can be classified based on the direction of displacement of the humeral head relative to the glenoid cavity.

1. **Anterior Dislocation (Most Common - 95%)**
    - **Subcoracoid (Most Common)**
    - **Subglenoid**
    - **Subclavicular**
    - **Intrathoracic (Rare)**
2. **Posterior Dislocation (2-4%)**
    - Seen in epileptic seizures, electric shocks.
3. **Inferior Dislocation (Luxatio Erecta)**
    - The humeral head is displaced below the glenoid.
4. **Superior Dislocation (Rare)**
    - Humeral head moves superiorly towards the acromion.

## Mechanism of Injury

- **Indirect Trauma:** A fall on an outstretched hand with the arm abducted and externally rotated.
- **Direct Trauma:** A direct force to the shoulder from behind, pushing the humeral head anteriorly out of the glenoid cavity.

## Etiology (Causes)

- **Traumatic Causes:** Falls, sports injuries, road traffic accidents.
- **Non-Traumatic Causes:** Generalized ligamentous laxity, repetitive microtrauma, congenital factors.

## Pathology

- The humeral head dislocates anteriorly due to excessive abduction and external rotation.
- Associated injuries:
  - **Bankart Lesion:** Avulsion of the anterior glenoid labrum.
  - **Hill-Sachs Lesion:** Compression fracture of the humeral head due to impaction against the glenoid rim.
  - **Axillary Nerve Injury:** Leading to deltoid paralysis and sensory loss over the lateral shoulder.

## Clinical Features

- **History:** Patient presents with sudden onset of pain following trauma.
- **Symptoms:**
  - Severe shoulder pain.
  - Inability to move the arm.
  - A feeling of "shoulder slipping out of place."
- **Physical Examination:**
  - **Loss of normal shoulder contour** – Flattening of the deltoid.
  - **Prominent acromion and humeral head felt in front of the joint.**
  - **Arm held in abduction and external rotation.**
  - **Dugas' Test:** Inability to touch the opposite shoulder.
  - **Hamilton Ruler Test:** A straight edge can touch both the lateral humerus and acromion simultaneously.

## Investigations

1. **X-ray Shoulder (AP and Axillary View)**
    - Confirms anterior displacement of humeral head.
    - Identifies associated fractures (Hill-Sachs lesion, greater tuberosity fracture).
2. **CT Scan (if needed)**
    - Provides a detailed assessment of glenoid bone loss.
3. **MRI**
    - Useful for detecting soft tissue injuries like Bankart lesion.

# Complications

## Early Complications

1. **Axillary nerve injury** - Weak deltoid muscle, loss of sensation over lateral shoulder.
2. **Brachial plexus injury** - Weakness of the entire upper limb.
3. **Fracture of greater tuberosity, surgical neck of humerus.**
4. **Rotator cuff tears** - More common in elderly patients.

## Late Complications

1. **Recurrent Shoulder Dislocations** - Due to capsular laxity and labral injuries.
2. **Post-traumatic arthritis** - Chronic pain and stiffness.
3. **Stiffness or adhesive capsulitis (Frozen Shoulder)**.

# Treatment

## Acute Management

1. **Closed Reduction under Sedation**
    - Techniques:
        - **Kocher's Maneuver:**
            - Traction, External Rotation, Adduction, Internal Rotation.
        - **Hippocrates Method:**
            - Surgeon uses their foot as a fulcrum in the axilla while pulling the humerus.
        - **Stimson Method:**
            - Patient lies prone with weight attached to the wrist to allow gravity-assisted reduction.
2. **Immobilization**
    - Shoulder immobilizer or sling for 3 weeks.
3. **Post-reduction X-ray**
    - To confirm reduction and rule out fractures.
4. **Physiotherapy**
    - Strengthening of rotator cuff muscles to prevent recurrence.

## Surgical Management

Indicated in:

- **Recurrent Dislocations (>2 episodes)**
- **Large Bankart lesion**
- **Associated fractures**

**Surgical Procedures:**

1. **Bankart Repair:** Reattachment of torn anterior glenoid labrum.
2. **Putti-Platt Operation:** Tightening of subscapularis tendon.
3. **Bristow's Procedure:** Transfer of coracoid process to anterior glenoid.

## Rehabilitation

- **Phase 1 (0-3 weeks):** Immobilization with pendulum exercises.

- **Phase 2 (3-6 weeks):** Strengthening of rotator cuff muscles.
- **Phase 3 (6+ weeks):** Return to sports-specific activities.

▼ Fracture of the Clavicle

## Overview

Fracture of the clavicle is one of the most common fractures, occurring across all age groups. It usually results from direct trauma, such as a fall on the shoulder or an outstretched hand. The clavicle plays a crucial role in shoulder movement and upper limb stability, making its fracture significant.

## Pathoanatomy

- The most common site of fracture is at the **junction of the middle and outer third** of the clavicle.
- The **outer fragment** is pulled downward and medially due to gravity and the **pectoralis major muscle**.
- The **inner fragment** is displaced upward due to the **sternocleidomastoid muscle**.

## Diagnosis

- **History:** Trauma with pain, swelling, and crepitus at the fracture site.
- **Physical Examination:** Tenderness, deformity, and possible shortening of the clavicle.
- **Neurovascular Examination:** To rule out injury to the **subclavian vessels** or **brachial plexus**.
- **X-ray:** Confirms fracture location and displacement.

## Treatment

- **Conservative Management:** Most clavicle fractures unite without surgery.
    - **Triangular Sling**: Used for minimal displacement.
    - **Figure-of-8 Bandage**: Provides immobilization and pain relief in displaced fractures.
    - **Early Mobilization**: Shoulder exercises start in 10-14 days.

- **Surgical Management:** Open reduction and internal fixation (ORIF) with a plate or nail in cases of:
  - **Neurovascular injury**
  - **Severely displaced fractures**
  - **Cosmetic concerns in young adults**

### Complications

- **Early Complications:** Injury to subclavian vessels or brachial plexus.
- **Late Complications:** Shoulder stiffness, malunion, or rarely non-union requiring bone grafting.

# 14. Injuries around the Elbow

▼ FOOSH

## Overview

A fall on an outstretched hand (FOOSH) is a common mechanism of injury that can lead to fractures and dislocations at various levels of the upper limb, depending on the age and impact force. The injuries can be categorized based on the site of involvement.

## 1. Shoulder Region

- **Clavicle Fracture** – Common in children and young adults. Usually occurs at the junction of the middle and outer third.
- **Anterior Shoulder Dislocation** – Most common shoulder dislocation due to forced external rotation and abduction.
- **Acromioclavicular Joint Injury** – Can range from sprain to complete dislocation of the joint.

## 2. Elbow Region

- **Supracondylar Fracture of the Humerus** – Common in children, caused by hyperextension at the elbow.
- **Radial Head Fracture** – Common in adults; presents with pain on forearm rotation.
- **Elbow Dislocation** – Posterior dislocation is common due to hyperextension injury.

## 3. Wrist and Hand Region

- **Colles' Fracture** – Distal radius fracture with dorsal displacement, common in elderly osteoporotic individuals.
- **Smith's Fracture** – Reverse of Colles' fracture with volar displacement.
- **Scaphoid Fracture** – Common in young adults; high risk of avascular necrosis.
- **Lunate Dislocation** – Can cause median nerve compression leading to carpal tunnel symptoms.

## 4. Forearm

- **Monteggia Fracture-Dislocation** – Fracture of the proximal ulna with dislocation of the radial head.
- **Galeazzi Fracture-Dislocation** – Fracture of the distal radius with dislocation of the distal radioulnar joint.

## Conclusion

FOOSH injuries vary based on the site of force transmission and patient demographics. Proper clinical examination and imaging are crucial for diagnosis and management.

▼ Supracondylar Fracture of the Humerus

## Classification

Supracondylar fractures of the humerus can be classified based on:

1. **Gartland Classification** (Most commonly used for pediatric fractures)
    - **Type I**: Undisplaced fracture.
    - **Type II**: Displaced fracture with intact posterior cortex.
    - **Type III**: Completely displaced fracture with no cortical contact.
    - **Type IV**: Multi-directionally unstable fracture.
2. **Based on Displacement Direction**
    - **Extension Type** (80% cases): Distal fragment is displaced posteriorly.
    - **Flexion Type** (20% cases): Distal fragment is displaced anteriorly.

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## Mechanism of Injury

Supracondylar fractures primarily occur due to **indirect violence**, mostly from a fall on an outstretched hand. The mechanism depends on:

- **Hyperextension Injury**: Most common; the elbow is forced into hyperextension leading to an extension-type supracondylar fracture.
- **Direct Trauma**: Less common; occurs due to a direct blow to the elbow.

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## Pathoanatomy

- The fracture line extends transversely across the **distal metaphysis** of the humerus, just above the condyles.
- The **distal fragment** may be displaced posteriorly (extension type) or anteriorly (flexion type).
- There is a high risk of damage to adjacent **neurovascular structures**, particularly the **brachial artery and median nerve**.

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## Displacement

The distal fragment of the humerus can be displaced in multiple directions:

1. **Posterior shift**
2. **Posterior tilt**
3. **Proximal shift**
4. **Medial or lateral shift**
5. **Medial tilt**
6. **Internal rotation**

These displacements affect the alignment and function of the elbow and can complicate management.

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## Clinical Features

- **History**: Usually seen in children with a history of a fall on an outstretched hand.
- **Symptoms**:
  - Severe pain
  - Swelling
  - Inability to move the elbow
- **Signs**:
  - **Posterior prominence of the olecranon** (due to posterior displacement)
  - **S-shaped elbow deformity**
  - **Loss of normal bony alignment** (the relationship between the epicondyles and olecranon is altered)
  - **Absent radial or ulnar pulses** (in case of vascular compromise)
  - **Median nerve involvement** (loss of thumb opposition, weak flexion of index finger)
  - **Radial nerve involvement** (wrist drop)

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## Investigations

### Radiological Examination

- **AP and Lateral X-rays of the elbow**:
  - Look for posterior shift or angulation.
  - Compare with the **opposite elbow** to confirm subtle fractures.
  - Evaluate for **fat pad sign** in occult fractures.

### Neurological and Vascular Assessment

- **Check radial and ulnar pulses** for vascular injury.
- **Motor and sensory testing** for median, radial, and ulnar nerves.

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## Complications

Supracondylar fractures are known for **serious complications**, which can be categorized as:

### Immediate Complications

1. **Injury to the Brachial Artery**:
   - The sharp edge of the proximal fragment may injure the brachial artery, causing ischemia.
   - Leads to **Volkmann's Ischemia** if untreated.
2. **Nerve Injuries**:
   - **Median nerve**: Most commonly injured.
   - **Radial nerve**: Can be affected, leading to wrist drop.

### Early Complications (Within 2-3 Days)

1. **Volkmann's Ischemia**:
   - Due to brachial artery occlusion.
   - Leads to **compartment syndrome** affecting flexor muscles.

### Late Complications (Weeks to Months)